JOURNAL

OF THE

New York Entomological Society.

Vol. XX. June, 1912. No. 2

THE BIOLOGY OF SOME WESTERN SPECIES OF THE DIPTEROUS GENUS EPHYDRA.[1]

By J. M. Aldrich,

Moscow, Ida.

(With Plates VII to IX.)

The investigation partially covered by this paper was first suggested by a casual visit to the shores of Great Salt Lake in the summer of 1908. The large number of new observations made in a couple of hours at that time indicated the existence of a rich and almost unexplored field. Through the liberality of the trustees of the Elizabeth Thompson Science Fund, I was enabled in the summer of 1911 to visit the principal salt and alkaline lakes of the Great Basin and adjacent territory west and southwest. The present paper combines the facts gathered in both years and those previously published, pertaining to the biology of the genus *Ephydra* in the west.

The bodies of salt and alkaline water visited by me in 1911, with dates of visits, are as follows:

Box Elder Lake, Utah ..... July 4 and 5
Great Salt Lake, Utah—
at Garfield (south end) ..... July 9
at Saltair (south end) ..... July 10
at Promontory Point (middle) ..... July 11
at Lakeside (west side) ..... July 12
Soda Lakes near Hazen, Nevada ..... July 13 and 14

[1] Being a portion of the results of an investigation carried on with the aid of an appropriation from the Elizabeth Thompson Science Fund.

Pyramid Lake, Nevada ..... July 16
Winnemucca Lake, Nevada ..... July 17
Mono Lake, Cal. ..... July 21 to 24
Walker Lake, Nevada ..... July 25
Owen's Lake, Cal. ..... July 28
Pacific Ocean at Santa Monica, Cal. ..... July 31
Lake Elsinore, Cal. ..... Aug. 2
Pacific Ocean at Long Beach, Cal. ..... Aug. 4
Borax Lake near Clear Lake, Cal. ..... Aug. 8
San Francisco Bay near Palo Alto, Cal. ..... Aug. 11

There are but four species of western *Ephydra* to report upon, as several of the names until recently in use are now known to be synonyms. All four of these are very abundant insects in their peculiar habitat, however, and one has been an important food for man. Several other species of the genus occur in the west, but their immature stages have not yet been found; so far as known they are all very rare. In another paper it is proposed to give a systematic treatment of the adults of all the western species.

Ephydra gracilis Packard.

Packard, Amer. Journal of Arts and Sciences, 3d series, I, 104, 1871, puparium only.

B. J. Jones, Tech. Bull., Cal. Ex. Station, I, No. 2, p. 159, 1906 (adult, as *Ephydra cinerea*).

Packard's original description, upon which the use of the name *gracilis* depends, is so brief that I quote it entire:

"These insects occur so abundantly where they are found, and can be so easily reared, that I venture to name another form from Great Salt Lake [the preceding had been from Clear Lake, Cal.—J. M. A.], specimens of the puparia of which have been communicated by Professor Verrill, from the collection of Mr. Sereno Watson; and by S. A. Briggs, Esq., of Chicago. It is much smaller and slenderer than any of the preceding species, the smaller specimens being .25 inch long, the largest .50 inch. The respiratory tube is much longer than in any species known to me, being in several specimens as long as the body itself; the branches into which it subdivides being over one third as long as the base of the tube. The body is of the shape of *E. halophila,* but is much slenderer, while the feet are larger and more prominent."

This description, as will be seen, consists only of a few general remarks about the puparium, comparing it with that of two other species; it would perhaps scarcely be recognizable but for the reference to the exceeding abundance of the species in Great Salt Lake. The description is especially unsatisfactory from the omission of a striking and easy mark of distinction, the basal filaments of the anal tube, which separates the species from all other American *Ephydras* of which the early stages are known. But it is certain that Packard was describing a strikingly small *Ephydra* common in Great Salt Lake, and there is but one species, whether he described it well or not.

Jones was dealing with specimens from Southern California, and was naturally unable to identify them from Packard's description. Mr. E. T. Cresson, Jr., examined Jones's' types and compared them with material from Great Salt Lake; he is inclined to retain the name *cinerea* for a large variety, but my material does not justify this.

Adult (Pl. VII, Fig. 1).—Length, 2.3 to 3.5 mm.; of wing 2 to 2.9 mm. General color opaque gray, paler below and with a slight greenish tinge above; front moderately bright green; legs infuscated, knees and greater part of the tarsi yellow; wing-veins yellow at base.

Head of typical *Ephydra* shape, the face not shining below the antennæ, front large, shining green except when viewed from in front with nearly frontal light, when it is ashy opaque; lower half of front with scattered minute hairs directed somewhat backward, no decussate small bristles; no noticeable impressions on front; frontal orbits pollinose, gray, with three bristles curving over the eye and a few small hairs arising between them; the edge of the front next the orbit is covered for a narrow space with a duller pruinosity; ocellar triangle pollinose, with two pairs of divergent hairs behind the single pair of large, divergent bristles; two vertical bristles each side, the inner curving directly mesad, the outer almost exactly laterad; occiput opaque, orbits not different, with only a small row of hairs. Antennæ black, gray pruinose, very short, rather far apart; first joint hardly visible, second nearly as long as third, with a slender erect hair at base and a notch in apex above just behind the arista; third without lateral hair, arista almost basal, short, thick at base, moderately plumose under high power. Face almost white all over, with scattered small black hairs and a row of three or four divergent and upturned long hairs each side above the middle, extending laterally close to the lower edge; lower edge of face with quite short and thin hairs hanging down, about the same in both sexes. Cheek behind lower part of eye rather large, with small hairs and one or two somewhat larger. Proboscis thick and short, black; palpi indistinctly yellowish.

Thorax opaque gray, with scattered small black hairs and the usual

black bristles for the genus, both on dorsum and sides; scutellum somewhat elongated, convex, hairy and with four bristles; sternopleural only one; several small bristles at posterior edge of mesopleura, one larger; halteres yellow. Abdomen rather uniformly gray pruinose with a little greenish tinge, first segment short, next three of equal length, fifth a very little longer; hypopygium small, narrow, blackish, with two yellowish stiff processes projecting forward as far as the middle of the fourth ventral; the longest hairs on the abdomen are about the apex and before the incisures near the sides, but they are hardly bristle-like. Coxæ and femora concolorous with thorax, the trochanters and knees yellow; tibiæ varying from yellow to the color of the femora, the front ones usually paler than the others; tarsi mostly yellow, variably infuscated at tip, longer than their tibiæ, the three middle joints of equal length, claws long, straight, black, no pulvilli. The hind femora have a long shining streak on the inner side, and the hind tibiæ have a short shining streak at the tip behind. Wings of ordinary structure, yellowish at base, especially the veins.

Larva (Pl. VII, Fig. 2).—Length in a full-grown, average specimen, of body, 10.6 mm.; of anal tube to the fork, 4.9 mm.; of each terminal fork, 1.6 mm.; of each basal fork, 2 mm. Color white, somewhat transparent. Eight pairs of rather long prolegs, the members in each pair united in a single tubercle in the basal third, but entirely separate on the remainder of their length; in front of the segment bearing the first prolegs there are three apparent segments, the foremost retractile, containing the jaw-capsule; the jaws, as in related forms, turn down in the form of hooks, and are not opposable. Behind the last pair of prolegs the body narrows suddenly into a long anal tube, which gives off close to the base on the under side a pair of long filaments, and at its tip divides into a pair of somewhat shorter filaments. The hindmost prolegs have a longer common tubercle and a shorter divided portion than the rest.

The anal tube is considerably retractile, and varies in length in different preserved specimens. It contains two tracheæ, which continue to the terminal fork, where one leads into each branch and ends in a vestigial spiracle at the tip. I doubt if these spiracles are ever put to the surface of the water; I have not yet seen it done, so I conclude that the whole structure has changed its mode of functioning, and operates as a tracheal gill.

Puparium (Pl. VII, Figs. 3, 4).—Length of body in an average specimen, to the last prolegs, 8 mm.; anal tube so variable that it can hardly be estimated, perhaps five or six mm. would be about the usual total length beyond the last prolegs. The form of the insect is much changed from the larval stage. The thickest part of the body is in the region of the third pair of prolegs, and it tapers suddenly in front, more slowly behind, so as to be somewhat fusiform with the thickest portion well before the middle. The prolegs toward the anterior end are small; the front pair are almost indistinguishable and have no hooks; the successive pairs are each a little larger, but only the last three pairs have hooks and are of about the same size as in the larva. The last pair, which in related species hold the insect attached

during the pupal period, are here but little if at all turned forward, and do not seem to serve an important function in this species. Behind the last prolegs the base of the anal tube looks like another body segment, those preceding it being about as slender as it is; the continuation of the tube is not strongly chitinized, but thin-walled and pale in color. The diverging terminal tubes each contain a trachea, which continue separate down into the body; the pair of filaments at base of tube do not seem to have tracheæ, at least they have no vestiges of spiracles at the apices as the terminal branches obviously have. At the front end of the puparium, there is a flattened space above, well defined, extending to hind edge of the segment bearing the first prolegs—only a short space, as the anterior segments become very small as the puparium forms; this plate cracks from the front end backward along each side, and sometimes allows the escape of the fly without the breaking off of the entire anterior end of the puparium, as is supposed to be the case in the group Cyclorhapha, to which Ephydridæ belong.

Pupa.—Upon removing the puparium, the enclosed pupa is readily obtainable. It is white in color and shows the outlines of the members of the future fly. The large proboscis is flattened down upon the prosternum; on each side of it the three legs are closely placed in regular order, and the wing follows the last leg; most of the dorsum of the thorax and abdomen is exposed, the wings being bent down along the side and of small size. It is difficult to make out many important features in the pupa, there being still one covering membrane over the future adult, and the tissues of the latter being still in an unfinished condition. The appearance is like the pupa of *E. hians*, in the half-tone, Fig. 15.

HABITS.

Distribution.—The insect is abundant in all parts of Great Salt Lake. It was reported to me by Mr. D. W. Coquillett as being represented in the United States National Museum from Salton Sea, Cal., and Tucson, Ariz. The material to which Jones gave the name of *E. cinerea* came from Southern California, without designation of locality. Recently a single specimen has been sent me by Professor C. F. Baker which was collected at Laguna Beach, Cal., which is on the Pacific Ocean. I have not learned the exact habitat of the insect in this case, but I presume it was found adjacent to some salt waters back from the sea-beach; it would be surprising to find it passing its larval stages in actual seawater.

My observations on the habits of the species were all made at Great Salt Lake, in the last of July, 1908, and the early part of July, 1911.

Egg and Early Larval Stages.—Of these I know nothing from

direct observation. Since most of the flies after maturity live on the surface of the water, the eggs no doubt are dropped directly into the water.

Food Materials.—There is an alga in the lake everywhere common, of the *Nostoc* group, its pulpy masses rolling up and down the beaches with the waves, and often forming rotting deposits of horrible odor along the upper beach as the level of the lake falls in summer. This I take to be the food of *gracilis* and also of the brine shrimp, *Artemia fertilis*, which are generally said to be the only forms of animal life found in the waters.

Habits of the Older Larvæ.—These seem to be suspended in the waters everywhere, wriggling rather aimlessly, often hard to see because of their half transparency. They do not show much disposition to keep near the surface; I could see them at a depth of two or three feet, which is as far as they could be made out on account of their delicacy. The probably occur at greater depths. That they do not come to the surface to breathe seems not to have been noted in this or any other species before, but I feel confident of my prolonged observations on this point. The long tube and its filaments must function as a tracheal gill, the spiracles at the tips being vestigial, as the anterior pair of spiracles certainly are. The pupæ show close to the anterior end the protuberant endings of a trachea on each side (Pl. VII, Fig. 7, shows the same in *hians*) so that if these and the posterior ones were functional we should have an amphipneustic larva. The anterior spiracles, however, are more vestigial than the posterior ones, and may be considered to have lost their function at an earlier period.

Puparia.—It is only in the pupal stage that the inconceivable number of these flies present in the lake begins to make an impression on the observer. The puparia are buoyant, regularly containing gas in the otherwise vacant space at the ends and around the pupa; moreover, they become attached to each other by the hardened and somewhat recurved forks of the anal tube, so that vast masses float along together. At Promontory Point I could see occasional large brown patches off shore, which I was assured were of this nature, and I was told that they were continually drifting down the Bear River Bay side of the Point, covering acres of water at a time and six inches deep, one informant said (I think he said forty acres).

The shores of the lake everywhere are more or less covered with windrows of puparia, which frequently form dark ridges that can be seen for a long distance. One of my half-tones (Pl. VIII, Fig. 8) shows the little bay on the north side, where the cutoff reaches the Point from the east. Here considerable drift accumulates, and the fly puparia form a mass filling the water close to shore, and a foot or more deep above the water for some distance; all the dark color in the water and along the edge is simply a collection of millions of puparia. The other half-tone of this subject is Pl. VIII, Fig. 9, which shows the shore on the south side of the railroad looking west. Here also the broad dark margin of the water is composed of puparia. Fig. 3 shows a small cluster of puparia held together by the diverging branches of the anal tubes. Fig. 4 is a small mass of puparia taken from a dry windrow on the beach near Garfield in 1908.

Adults.—The adults are found on the surface of the water all over the lake, but along the beaches they gather in large numbers, probably because they emerge there from the windrows of puparia that wash up. On July 31, 1908, I visited the shore near Garfield, at the south end of the lake. Near the rocks which come down to the edge of the water at the county line, I waded in and investigated the flies. At that time the surface of the water from the shore out for a distance of about eighteen feet was perfectly covered with the adult flies. They made a black belt along the beach that was visible for several miles, or as far as the shore line could be seen. They were crowded closely together, and when disturbed by my near approach they would rise only a few inches and immediately settle again. They extended up the beach a few feet above the water also, so the average width of the mass was over 20 feet. I thought that there were more than 25 flies to the square inch; in fact, double that seems a small estimate. The minimum estimate would give about 370,000,000 flies to the mile of beach.

In bathing at Saltair, I heard one bather say to his companion, "Don't go near those piles, you'll get covered with gnats." This was in allusion to *E. gracilis,* which I found on examination was present in large numbers, but as I could see it on the surface of the water everywhere it did not seem especially bad about the piles. There is occasional complaint about "gnats" by the bathers, but the flies

are very small and inconspicuous and do no harm further than to walk on people.

On the Southern Pacific cut-off west of Ogden the fly appears in a new rôle. The train-men pass through the train a few minutes before the lake is reached, shutting the windows "on account of the salt-flies," as I heard one say. It appears that the suction of the moving train raises the flies much above the usual level of their flight, and they come into open car windows by myriads. Even with care in closing the windows some will find their way in, where they become a nuisance by walking on passengers and on the tables in the dining cars. I had no difficulty in finding some of the flies in the latter situation as far west as Reno, Nevada, and I doubt not that they may be found after the cars reach Oakland. Reno is approximately 500 miles west of Great Salt Lake.

Nor is the story of *gracilis* yet completed. In the summer evenings they congregate on the rails of the cut-off to such an extent as often to stop the gasoline motors used by track-men, and even sometimes to stall freight trains. Pl. VIII, Fig. 10, shows as good a picture as I could make with a regular kodak of flies on the rails; it was taken on the morning of July 12, 1911, at Lakeside, on the western shore of the lake.

From Saltair bathing pavilion I walked ashore, and near the railroad in a little bay I found a place where the salt water had evaporated down until it was full of salt crystals. Even here the larvæ of *gracilis* were active and unconcerned. I found none of them, however, in fresh water a short distance away from the lake, nor in that which was tolerably brackish, although a few adults were present sometimes at a little distance from the salt waters. Professor Voorhies at the University of Utah informed me that he had left larvæ of *gracilis* in water that had evaporated down until it was covered with a crust of salt, and even in this condition the insects were active; also that he had on one occasion kept some of them in a histological fixing solution over night and for several hours of the following day, before they succumbed to the poison.[1]

[1] Wilcox, in *Anat. Anzeiger*, XII, 278, describes the remarkable resistance of a dipterous larva from stagnant salt pools at Newport, R. I. He identified it with doubt as a Helophilus, but I suspect it may have been an Ephydra.

Ephydra hians Say.

Say, Jour. Acad. Sci. Phil., VI, 188, 1830. Original description of adult; habitat Mexico; reproduced in Say's Complete Works, II, 371.

Loew, Centuries of N. A. Dipt., VI, 88, 1865. Adult described as *Ephydra crassimana;* habitat Mexico.

Packard, Amer. Journal of Science and Arts, 3d ser., I, 103, 1871. Larva, pupa and puparium described as *Ephydra californica;* habitat, Clear Lake, Lake Co., Cal., supposed to be salt water: puparia from Mono Lake probably the same.

Williston, Transactions Conn. Academy, VI, July, 1883, sep. p. 4. Describes adult supposed to be that of *californica* Pack., from Soda Lakes, Nevada; notes on larvæ in these lakes and at Mono Lake, and use as food by Indians.

Williston, North Amer. Fauna (Bull. 7 pt. 2, Div. of Ornith. and Mammal., Dept. of Agric.), p. 257. Adult described as *Ephydra tarsata,* from Owen's Valley, Cal.[1]

Adult (Pl. IX, Fig. 18).—Black, opaque gray all over except the front, which is shining dark green; first joint of front tarsus considerably thickened in the male. Front with scattering small hairs except in the somewhat depressed middle portion, toward the sides anteriorly with three or four pairs of bristles of different sizes, the largest decussate; the shining part of front narrowed anteriorly, and the opaque sides becoming wider; two vertical bristles on each side, the tips of the inner pair almost meeting; ocellar triangle opaque, with three pairs of bristles, becoming smaller posteriorly; frontal orbit with four curved bristles; face prominent in the middle, rather densely hairy all over, longest on the lower edge; rather bushy hairs below the eye and behind its lower part; antennæ of medium size, first joint distinct, second with an erect hair, third without a lateral hair, arista short, thick at base, nearly bare.

Dorsum of thorax with plentiful coarse hair, besides the usual bristles; many of the hairs approach the size of bristles, making the chætotaxy confused—however it is easy to count *six* dorsocentrals, 3 humeral, 2 presutural, 2 large median prescutellar; scutellum with coarse hair and two pairs of bristles, sometimes another small pair between the main ones; pleura concolorous, the mesopleura, propleura and sternopleura all hairy, mesopleura with a row of bristles on hind edge, stenopleura with one bristle; metanotum and remainder of pleura bare.

Abdomen concolorous, the greenish ground-color showing through a little more than on other parts of body, both dorsal and ventral sides coarsely hairy; hypopygium of male small, generally retracted; tip of abdomen of female with the usual two spines curved backward below.

[1] In making out the above synonymy I have been aided by suggestions from E. T. Cresson, Jr., and the late Mr. Coquillett, of the National Museum. As will appear, we have to deal with a very widespread form, which has been partially described several times.

Legs wholly opaque gray pruinose, tarsi with brush-like pale hairs below, front metatarsus of male somewhat thickened, and with curled hairs on outer side, making the middle of the joint appear wider than it is; hind femur with a wide shining black area on the inner side, beginning near the base and extending beyond the middle; hind tibæ with a very narrow shining black line on the hind edge at the tip, extending up the tibia only one sixth its length. Claws very long and straight, no pulvilli.

Wings as in halftone, veins black, brownish-yellow at base; costa with a few short spinules beyond middle.

Length, 3.2 to 5.6 mm.; of wing, 3.5 to 4.5 mm.

DISTRIBUTION.

Washington: Soap Lake (C. V. Piper, in State College coll.). Lake Como (U. S. National Museum, reported by D. W. Coquillett).

Oregon: Albert Lake (U. S. N. M.).

California: Borax Pond near Clear Lake. Clear Lake (Packard —probably was actually the same as the preceding, as Clear Lake is fresh water). Mono Lake (several collectors). Owen's Lake and Valley (several). Borax Lake and East Lake (U. S. N. M., without further information as to where these are).

Nevada: Soda Lakes (Williston). Lagoon south of Pyramid Lake (U. S. N. M.). Pyramid Lake.

Utah: Great Salt Lake (U. S. N. M.).

Wyoming: 12 miles north of Lusk (U. of Kansas coll.; no data as to body of water).

Nebraska: Salt Marshes near Lincoln (L. Bruner).

Minnesota: Red River Valley (Washburn; no data as to body of water).

Mexico: Guanajuato and Lake Texcuco (U. S. N. M.). Without locality (Say and Loew).

Pupa (Pl. IX, Fig. 15).—Specimens of these were extracted from the puparia and photographed. As in *gracilis,* they seem to present no characters of importance in classification or biology.

Puparium (Pl. IX, Fig. 16).—Length 7 mm.; of tube to fork, 2.6 mm.; of fork, 1.1 mm. Spindle-shaped, strongly tapering and up-curved in front, more gradually tapering and straight posteriorly; first four pairs of prolegs small but provided with strong hooks; last four pairs large and protuberant, the last pair largest and longest, and the hooks reversed in position; on the posterior side of this segment are some small protuberances which in some cases appear like additional but rudimentary prolegs, but they vary in development in different specimens; there are some bulging spots on the shell on

the two segments preceding this one, but they have no regular arrangement. The dorsum of the puparium is pigmented in a broad irregular vitta almost the whole length, as in the larva. The anal tube has no basal forks or filaments; the tube and its terminal forks are more uniform in length than in the larval stage, being of a hard consistency. The segment which bears the first prolegs has a flattened surface above, which continues to the anterior end of the puparium; this somewhat shield-shaped piece splits along the sides, and many of the flies emerge from the crack without pushing off the entire front end (Fig. 16, arrow) as is supposed to be characteristic of *Diptera cyclorhapha*. The flat upper piece is readily removed, and is shown in Fig. 7. It bears at the sides the rudiments of two spiracles. The lower portion of the anterior end also readily cracks off, just behind the first prolegs, and is shown in Fig. 17; it contains the remains of the mouth-parts of the larva —a flat black sclerite embedded in the integument, and the jaw-capsule frame farther back, to the front edge of the latter being attached two long curved hooks, which in the figure seem to connect it with the former, but which really bend downward at their points. As the pupa forms it retracts from the anterior end of the shell and leaves these larval organs outside.

Larva (Pl. IX, Fig. 13).—The fullgrown larva measures about 12 mm. in length in alcoholic specimens; the length of the anal tube and its forks is highly variable and depends entirely on the amount of retraction that has taken place; generally it is much shorter in preserved specimens than it is observed to be in fresh material. The most prominent characteristic of this species is the highly pigmented stripe down the back, almost as wide as the larva, with irregular edges, narrower toward the front edge of each segment and then gradually widening to the posterior border. This pigmentation shows under the high power of the compound microscope as a covering of minute spines, a sort of shagreen; but with moderate powers it simply appears like a blackish pigment. The eight pairs of prolegs are conspicuous, as in allied forms, the last pair being much the largest, with the hooks reversed in position, enabling the insect to grasp a solid object between them and the next pair anterior, or sometimes the second pair anterior. This is a very characteristic feature of the species. The anal tube bears no filaments at base, and the apical ones emerge directly from the open end of the tube, into which they can be drawn so that only the tips are visible. The spiracles at the end of the two forks appear to be non-functional, and as in *gracilis* the organ serves as a tracheal gill.

The part of the insect anterior to the segment bearing the first prolegs is considered by Brauer to consist of five segments (Denksch. Kais. Ak. Wiss., XLVII, 39, 1883), but of these only three can be discerned, the other two being retracted in the anterior end. The second of the visible segments bears on its under surface a large, transversely oblong black spot or sclerite: this seems to be a hardened spot in the integument for the attachment of some of the muscles of the jaw-capsule. There is no true head, the retracted part being mainly the jaw mechanism. Two minute two-jointed antennæ can sometimes be detected, but they are capable of retraction. The jaws are

modified so that they work vertically, as in all this group; in *hians* they are provided with a transverse row of teeth.

As in the case of other cycloraphous dipterous larvæ, distinct stages separated by moulting are not found. I have numerous newly-hatched larvæ, and a few of intermediate sizes. The youngest sizes differ from the full-grown in several minor features, especially in the absence of dorsal pigmentation and of the black plate on the ventral side of the (apparent) second segment; also in the presence of a large number of hooks in the mouth, almost like those of a pair of prolegs. These last are retractile, and not visible in some small specimens: I am unable to determine at what stage they are lost. They are well developed in larvæ 2.5 mm. long, and in smaller ones.

Egg (Fig. 11).—Length .8 mm.; width, greatest, one-third the length, least, one-fourth the length. Slightly curved; white in color. Without any hairs or appendages, quite unlike those figured by Jones for *E. millbræ*. Not attached to anything, as far as my observations go.

HABITS.

The adult flies are abundant at the edge of the water of many western salt and alkaline lakes and ponds, as indicated to some extent under distribution. I first observed them in July 31, 1908, near Garfield, Utah, on the shore of Great Salt Lake. While *gracilis* occupied all the water's edge and extended out on the surface of the lake for some distance, *hians* occurred in numbers a little farther up the lake beach, where there were windrows of rotting material that had been washed up at a higher stage of water not very long before. The two species seemed not to mix much, and my impression at the time was that *hians* bred in the rotting *Nostoc,* etc., of the windrow. On visiting the lake at several points in 1911, at a season when *gracilis* was not so overwhelming in numbers of adults, I found *hians* occasionally abundant close to the margin of the water and walking out on the surface for a few feet. Neither of these two species appears to live in water of slight alkalinity or saltness, except when it is very close to more dense water. To illustrate, at Promontory Point I was taken to inspect a spring a mile and a half up the east side of the ridge; it was about half a mile from the lake, and several hundred feet above it. The water was only brackish to the taste, but both *gracilis* and *hians* were abundant. The small outflow was lost in the dry earth in a short distance but probably sometimes did reach the shore, giving the flies a chance to follow it up. Again, Pyramid Lake is nearly fresh water, somewhat alkaline to the taste, but probably passable to

drink in an emergency. I found *hians* in small numbers near the inlet; but this was within perhaps a mile of "Mudhen Lake," a much more alkaline pond close to the Truckee River just south of the Lake (doubtless the one called a lagoon in the distribution, above), where I was informed by an Indian that the Kootsabe was abundant—this same fly. Except in these two cases, I have not found *hians* except at the decidedly strong waters, but it appears to thrive well in both salty waters and alkaline, while as far as known at present *gracilis* confines itself to the former only. Neither fly seems to spread much from the immediate edge of the strong waters, though near Garfield I found *gracilis* a few hundred feet back from the main lake, at the edge of nearly fresh water. Professor Voorhies told me that he had not tried the experiment of rearing *gracilis* in pure water, and I did not stop long enough in a place to undertake it myself.

Adults of *hians* have the unusual habit of entering the water and walking about on objects below the surface, enveloped in a globule of air. They cannot descend unless they can have some solid object to hold to, as they are quite buoyant when below the surface. I repeatedly saw them walking in this way in Mono Lake, clinging to stones, wood, grass, cloth, or any firm substance; when they wished to come to the surface they did so by letting go and floating straight up, when the enveloping bubble bursts at the surface, and the fly is left standing unconcernedly on the top of the water. This is very common, and in one case I found eggs that had been laid on an old cloth some distance below the surface, on which I had seen numerous flies. This is not the invariable mode of laying eggs, as a great many of the flies are far from shore, over deep water, and have no way of getting below the surface. It seems pretty certain that in such a situation the eggs are simply dropped in the water while the fly rests on the surface.

The larvæ are generally found near the bottom of the water. They wriggle a good deal, but do not come to the surface for air, having become modified in the same way as *gracilis* in regard to respiration. I never saw *hians* about the Saltair bathing pavilion, and think it likely that both larvæ and adults generally remain rather close to shore. The food of the larvæ I did not investigate, thinking that it would be a simple matter to open some of the preserved specimens and identify the contents of the proventriculus; the operation proved

very unsatisfactory, however. In Mono Lake, where I made most of my observations on this species, there seemed almost nothing in the beautiful, clear water of a vegetable nature. This larva and the brine shrimp *Artemia monica* were the only visible animals.

When the larvæ have reached their full size, the outer integument hardens into the puparium. Before this takes place the insect has already assumed the fusiform shape of that stage, and has taken a firm hold on some solid object for attachment. The hold is taken by grasping the object between the last prolegs and the next pair forward, or the second pair forward. They attach to any firm object, roots of vegetation being much used. At the small Soda Lake in Nevada, I took up a piece of string out of the water which was literally covered. They often attach to each other, and sometimes an empty but still attached puparium is utilized by thrusting the last two or three segments into the open end and pressing the next prolegs against the outside. When the larva contracts into the pupa, the space left within the puparium becomes full of gas, so that the insect floats if detached, although normally it remains in the bottom of the lake. The fly on emergence is enveloped in the bubble of gas, and floats at once to the surface; this process I witnessed several times.

Mono Lake is subject to violent winds in the latter part of summer, and the disturbance of the lake loosens many of the puparia, so that they float to the surface and wash ashore. The late Professor Wm. H. Brewer, of Yale, made some observations here in July, 1863; I quote a portion of his letter to Williston (published by Williston, Trans. Conn. Acad., July, 1883):

"They drift up in heaps along the shore, and *hundreds of bushels* could be collected! They only grow at certain seasons of the year, and then Indians come from far and near to gather them for food. The worms are dried in the sun, the shell rubbed off by hand, when a yellowish kernel remains, like a small yellowish grain of rice. This is oily, very nutritious, and not unpleasant to the taste, and, under the name of *koo-chah-bee* (so pronounced), forms a very important article of food. . . . My guide, an old hunter there, told me that everything fattens in the season of *koo-chah-bee;* that ducks get very fat, but their flesh tastes unpleasantly from it, and the Indians get fat and sleek."

My stay at Mono Lake was July 21–24, 1911, and I was informed

that the collection of the fly for food would not begin until about September 1. None was left over from the previous year, so I was disappointed in seeing either the material after preparation or the process of putting it up. However, I talked with both Indians and whites about it. There are only a few Indians who collect the material now, although it is known among all the older Indians of the tribe. The name of the food is better spelled "koo-tsabe," accented on the first syllable, the last two letters forming an obscure syllable in which it is hard to distinguish whether the consonant is b or v. "Fat Joe" pronounced it for me many times and I listened very attentively; when I told him it had not been so recorded by earlier investigators, he chuckled and replied in his free and easy English, "Well, you understand I'm giving you the real thing." White people at the lake emphasized the amount of time required to free the little dried pupæ from bits of puparium, dirt, etc.; they thought it hardly worth while for anyone to work at it whose time had any value.

Most of the Pah-Ute Indians are now on reservations, one south of Pyramid Lake and one at the north end of Walker Lake, and only a few live near Mono Lake, where they eke out an existence on koo-tsabe, dried caterpillars (which I have reported on elsewhere) and pine nuts, adding a minimum of white man's "groceries."

The accompanying half-tones of the pupæ will give some idea of the food material that the fly makes. It has been reported that it was also collected thirty or more years ago by Indians of the same tribe at the two small soda lakes near Hazen, Nevada.

The loss of my camera with all my exposed films in it, while I was at Mono Lake, makes it impossible for me to give any illustrations except from the material brought home—much to my regret, for the lake and surroundings are very beautiful and picturesque.

The main centers of this species might be said to be Mono Lake, Owen's Lake, and Great Salt Lake—in all three they are exceedingly numerous.

I cannot forbear to include a brief extract from Mark Twain's "Roughing It," about the characteristic fly of Mono Lake, as it is true to life: "You can hold them under water as long as you please they do not mind it—they are only proud of it. When you let them go, they pop up to the surface as dry as a patent-office report, and

walk off as unconcernedly as if they had been educated especially with a view to affording instructive entertainment to man in that particular way."

In Williston's Manual of North American Diptera, 2d edition, 1896, p. 109, there is a quotation from a letter written by Professor Penafiel, referring to a species said by Williston to be *E. hians*, which is used as food at Lake Tezcuco, an alkaline lake about a hundred miles west of Mexico City. The quotation follows:

"It is of the eggs of this insect that the greater part of what is known as Ahuatle is composed and which is now used by the natives who have preserved the customs of the ancient Aztecs. The eggs are cleaned and ground into flour, and are prepared by mixing with hens' eggs and fried with fat into small cakes. The larvæ are also used as food under the name of Puxi."

Packard, in a footnote to his second paper on "Insects Inhabiting Salt Water," quotes something similar from a book called "Anahuac," by E. B. Taylor, published in London, in 1861. The quotation is as follows: "A favorite dish here (Tezcuco) consists of flies' eggs (*Corixa femorata* and *Notonecta unifasciata*, according to Menneville and Vielet d'Aoust) fried. These eggs are deposited at the edge of the lake, and the Indians fish them out, and sell them in the market place. So large is the quantity of these eggs that at a spot where a little stream deposits carbonate of lime, a peculiar kind of travertine is forming which consists of masses of them imbedded in the calcareous deposit." Packard adds without specifying his authority, "The flies which produce these eggs are called by the Mexicans 'Axayacatl' or 'water face.' The eggs are sold in the market, pounded and cooked, and also in lumps *au naturel*, forming a substance like the roe of a fish. This is known by the characteristic name of 'ahua-utli,' that is, 'water wheat.'"

It seems that the Diptera and the Hemiptera are mingled together in the quotations; only an investigation by an entomologist at the lake can clear up the confusion. Probably the egg state is not used in either insect.

There remains only a brief note to add about the identity of Packard's *Ephydra californica*. After I learned that Clear Lake is a body of fresh water, not salt as Packard supposed, I inquired about any small bodies of alkaline water in the vicinity; in fact, Professor

A. J. Cook, now Horticultural Commissioner of California, told me of one before I could ask him. Later Dr. E. C. Van Dyke gave me full directions about reaching the place. It is a small, strongly alkaline pond close to the shore of Clear Lake, some three or four miles south of Soda Bay, and is called Borax Pond or Borax Lake. I made a special trip from San Francisco, taking two days' time, and was successful in collecting *E. hians* at this borax pond. This, I think, makes it reasonably certain that *californica* is a synonym of *hians.*

Ephydra subopaca Loew.

Loew, Centuries, V, 99, 1864. Adult described from Connecticut.

Packard, Proceedings of the Essex Institute, VI, 46, 1868 (issued March, 1870); puparium and adult described as *Ephydra halophila,* a preoccupied name; from brine at Equality Salt Works, Gallatin Co., Ill. Synonymy by Coquillett, *in litt.*

Johnson, Proc. Acad. Nat. Sciences of Philadelphia, 1895, 339, occurrence at Charlotte Harbor, Fla.

Smith, Catalogue Insects of New Jersey, 1899, 693, occurrence in New Jersey; second edition, 1909, 807, same, several localities.

Johnson, Entomological News, XV, 163, 1904, oc. at Atlantic City and Seaside Park, N. J.

Adult (Pl. VII, Fig. 5).—A yellow-legged species with rather dense yellow pollen, front metallic blue-green, the fifth segment of the abdomen in the male nearly twice as long as the fourth.

Front metallic blue-green, bright, in the female with a pair of small decussate bristles on the lower part of the front and several hairs above and below these as well as a few scattering small hairs along the sides of the shining portion; in the male these hairs and bristles of the front are little developed; three orbital bristles, with hairs intermingled; two verticals each side; behind the main pair of ocellar bristles are two pairs of hairs; orbits yellow-pollinose. Face yellow-pollinose, with a small shining bluish spot in the median line below the antennæ, covered with small black hairs and two transverse rows of bristles, one of which is directed downward along the margin of the mouth and is composed of long bristles in the female; the other follows the upper edge of the protuberance and the bristles bend outward and upward, especially those near the middle. Eye small and oblique, one large bristle on the broad cheek. Palpi yellow. Thorax yellow pollinose, dorsum a little shining in some specimens (when abraded), covered with small black hairs. Dorsocentrals 4 (1 before the suture), prescutellars one median pair, humerals 1 and several hairs, posthumeral 1, presutural 1; scutellar two pairs; before the scutellum the hairs are noticeably long. Mesopleura hairy except on the front part, on its hind edge with a row of long hairs and one bristle; stenopleura hairy and with one bristle. Tegula yellow, with abundant pale

yellow silky hairs. Halteres yellow. Abdomen concolorous with thorax or more greenish, with black hairs, longer on the posterior edge of the segments, fifth segment in male nearly twice as long as fourth on dorsal side, ventrally it is entirely cut away to receive the large hypopygium, which has a pair of yellow processes extending forward one third the length of the fourth segment. Legs usually yellow, middle and hind coxæ blackish, tarsi somewhat infuscated toward the tip; front femora with some bristles on the outer and upper side; hind femora with a long shining area on the inner side, destitute of hairs, extending the whole length; hind tibia with a narrow shining streak on the hind side, from below the middle to the apex. Wings yellowish, veins yellow on basal half.

Length, 4 to 5 mm.; of wing, 3.5 to 4.5 mm.

This species varies in several ways: the yellow color of the pollen may vary to whitish, especially on the face; the color of the legs may be considerably infuscated, especially on the femora; the hairs of the front may vary considerably in size; and the shining spot on the upper part of the face may be absent. As all these variations may occur in a lot taken together, they do not indicate specific differences.

Larva.—My material is far from abundant, but will allow a comparative description with *hians*. The larva of *subopaca* differs in not having the dorsal pigmentation and the black integumental plate below the retracted jaw-capsule. The color is almost white, but the tips of the forks of the anal tube are very *black,* contrasting more with the general color than in *hians*. There are no basal filaments from the anal tubes. The proportions of body and tube are about as in *hians,* but the size a little smaller.

Puparium.—There are faint pigmented spots on the dorsum. The sixth and eighth pairs of prolegs are uniformly large, the last with hooks directed forward; these two pairs are used in grasping a support while in the pupal period, the anterior five and the seventh being small but with good-sized hooks. The color of the integument varies but is generally light, and in many specimens the macrochætæ of the pupa can easily be seen through the puparium—often indeed small hairs as well. The flat or concave region of the anterior end above is strongly marked, and the rudimentary spiracles stand out laterally on the (apparent) first segment, their protruding part divided into three or four processes.

DISTRIBUTION.

Massachusetts: Woods Hole (Melander).

Connecticut (Loew).

New York: Ithaca, at salt pond (Johannsen).

New Jersey: several localities (Smith Catalogue).

Illinois: Gallatin Co., at salt pond (Packard).

Utah: Box Elder Lake (salt). Garfield (brackish seepage). Promontory Point (brackish spring).

Idaho: Market Lake (overflow from irrigating ditch).

Nevada: Hazen (overflow from irrigating ditch). Winnemucca Lake (alkaline). Walker Lake (alkaline).

California: Mono Lake (seepage near lake).

Washington: Soap Lake, Grand Coulee (alkaline).

Habits.

Comparing my observations of this species with those on the two preceding, a striking difference appears in the density of the water in which they live, as *subopaca* occurs only in the less dense waters, often in those with a specific gravity scarcely more than 1. The other two, as already stated, seem not to occur except in the dense water or near it.

In Box Elder Lake, a shallow expanse of slightly salty water two miles north of Brigham, Utah, I found this species, the first *Ephydra* of my trip. Using a hydrometer, I attempted to find out the density preferred by the species, and here I learned my first lesson, emphasized all the way afterward—that in all these bodies of salt and alkaline water, the density is subject to great fluctuations, and the insects are able to adapt themselves to these. Along the side of the railroad grade a stream of waste irrigating water ran into the lake; it was possible to find all densities from 1 to 1.019, and the larvæ of the fly, though not numerous, seemed at home everywhere, or at least to a density of 1.001. A few days later, near Garfield, Utah, *subopaca* was found around waste water, sp. gr. 1.00; but it was seepage that perhaps contained too little alkaline matter to be detected by my instrument. I have recorded under distribution several cases like this, and the interesting question is still unsettled whether some small amount of salt or alkali is not a necessity in water that is to support larvæ of this species. The adults are often found at fresh water if it is near a denser supply; in the road near the Mono Lake post-office this was especially in evidence, where there was a seepage of very pure water with plenty of *subopaca* adults standing on it (the adults generally stand on the water, not on the shore).

At Bodie, Cal., an old mining camp on the top of a mountain range at an elevation of 8,400 feet, there were specimens of what I took to be this species (certainly an *Ephydra*) standing on the surface of reddish seepage water from a manure pile.

It is everywhere more difficult to find the larvæ of this species than of the two preceding; I found them only twice. This may be on account of the adults moving farther from the place of emergence than in the other species, or possibly they form more distinct broods, so that no larvæ are left behind, but all transform nearly together.

Packard's notice of what he called *halophila* contains the following quotation from his correspondent (E. T. Cox) at the Equality Salt Works:

"I send you the larva and pupa of a dipterous insect (*Ephydra*) found in the brine at the salt works near Equality, Gallatin Co., Ill., in such prodigious quantities as to fill up the wooden conduit pipes. These larvæ [puparia—Packard] are gregarious, collecting in masses and form great rope-like bunches by clinging around small fibrous roots on the sides of the little ditch that conveys the brine from the first 'Graduation or Thorn House,' to the pump at the furnace. The brine as it comes from the well has a strength equal to 7.3 Baumé, and is graduated after the German plan, by showering it successively over thorn bushes arranged on beams from top to bottom of three separate frames, from forty to forty-five high, called 'Graduation or Thorn Houses.' What is remarkable in this is, that the above larvæ can nowhere be found except in the brine after first gradation, that is, passed over the first house, where they are found in such quantities as to prove a great nuisance."

A similar case is reported to me from brine pools near the salt works at Ithaca, N. Y., by Dr. O. A. Johannsen, now of the Maine Experiment Station, who sent me specimens for identification. The larvæ in this case were found in pools of varying density, ranging from 1.5 to 6.5 grams of salt per liter of water. The noticeably greater density of the water in the case quoted by Packard is as yet unexplained; no further observations at that place have been made.

Ephydra Millbrae Jones.

Jones, Tech. Bull. Cal. Ex. Sta., Vol. I, No. 2, pp. 155–159, 1906. Adult, pupa, puparium, larva and egg described; several figs. Breeding in salt marshes on southwest side of San Francisco Bay, Cal.

This species (Fig. 6) is closely allied to *subopaca*, if not even identical with it. The primary difference in the adult is the darker color of the legs, the femora being dark greenish with a slight metallic

luster, the tibiæ yellow with infuscated tip, the tarsi infuscated. The average of size is slightly larger, and the hairs and bristles are slightly longer, than in *subopaca*. The color of the pollen over the body is more greenish in *millbræ*, yellowish in *subopaca*. Occasional specimens with lighter pollen and yellow legs occur in *millbræ*, the lightest ones corresponding exactly with the other species; just as, among the *subopacas* of the interior, dark-legged specimens are occasionally seen. In either case 98 per cent. or so are true to type. As I have not studied the larva and puparium of *millbræ*, I feel that it would be premature to assert the identity of the two species.

The puparium as figured and briefly described by Jones seems to be the same as in *subopaca*. His figure and description of the larva indicate a small amount of dorsal pigmentation and a larger development of the anterior spiracles, but the examination of material in both species would be needed to determine whether a specific difference exists here. The egg according to Jones is shaped like an appleseed, and has tufts of minute hairs on its surface; it is attached by its larger end to floating bits of vegetation or puparia.

DISTRIBUTION.

Jones mentioned portions of San Francisco Bay, from San Mateo to San Bruno. I have collected it in the following localities:

Salt marshes of S. F. Bay adjacent to Palo Alto, in February, April, August and October.

Alum Rock park, near San Jose, Cal., 20 miles or so from the bay, April 5.

Santa Monica, Cal., July 31.

San Juan Island, Wash., several places, May to July.

Professor C. F. Baker sent me a specimen collected at Laguna Beach, Southern Cal.; while I am indebted to Professor Melander for specimens taken May 17 at Olga, on Orcas Island, Wash.

HABITS.

The species keeps close to the seashore. The Alum Rock record above is the only apparent exception, and there the park with numerous mineral springs is traversed by a stream which empties, or at one time did, into San Francisco Bay.

Jones says: "Like mosquitoes, they seem unable to breed in water affected by the tide, but prefer the smaller pools that are practically without motion. . . . I have found the flies living in ponds where the salinity was as high as 4.2 per cent., being almost one per cent. higher than that of average sea water. . . . The adult flies abstract their nourishment from the surface of the water in which their larvæ live. They are especially fond of decaying animal matter, and will collect in swarms on water containing dead crabs or other animal bodies."

At Santa Monica the species was abundant July 11, 1911, on the surface of a pool at the mouth of Santa Monica Creek. The creek is small, and disappears in the sand as it approaches the beach. Here there was a pond some 15 feet wide and 70 long, with no visible outlet or inlet, on which were the flies, but in which I could find no larvæ even in prolonged search.

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. *Ephydra gracilis* Pack., adult ♀, × 8.

Fig. 2. *Ephydra gracilis* Pack., nearly full-grown larvæ, × 4½.

Fig. 3. *Ephydra gracilis* Pack., cluster of puparia hanging together by anal tubes, × 3.

Fig. 4. *Ephydra gracilis* Pack., mass of dried puparia from Great Salt Lake beach, slightly reduced.

Fig. 5. *Ephydra subopaca* Loew, adult ♀, × 8.

Fig. 6. *Ephydra millbræ* Jones, adult ♀, × 8.

Fig. 7. *Ephydra hians* Say, dorsal anterior dehiscent portion of puparium, enlarged (see Fig. 16, arrow).

PLATE II.

Fig. 8. Looking east from Promontory Point, Utah, along the S. P. cut-off. The dark material collected in the bay in the foreground is *Ephydra gracilis* puparia.

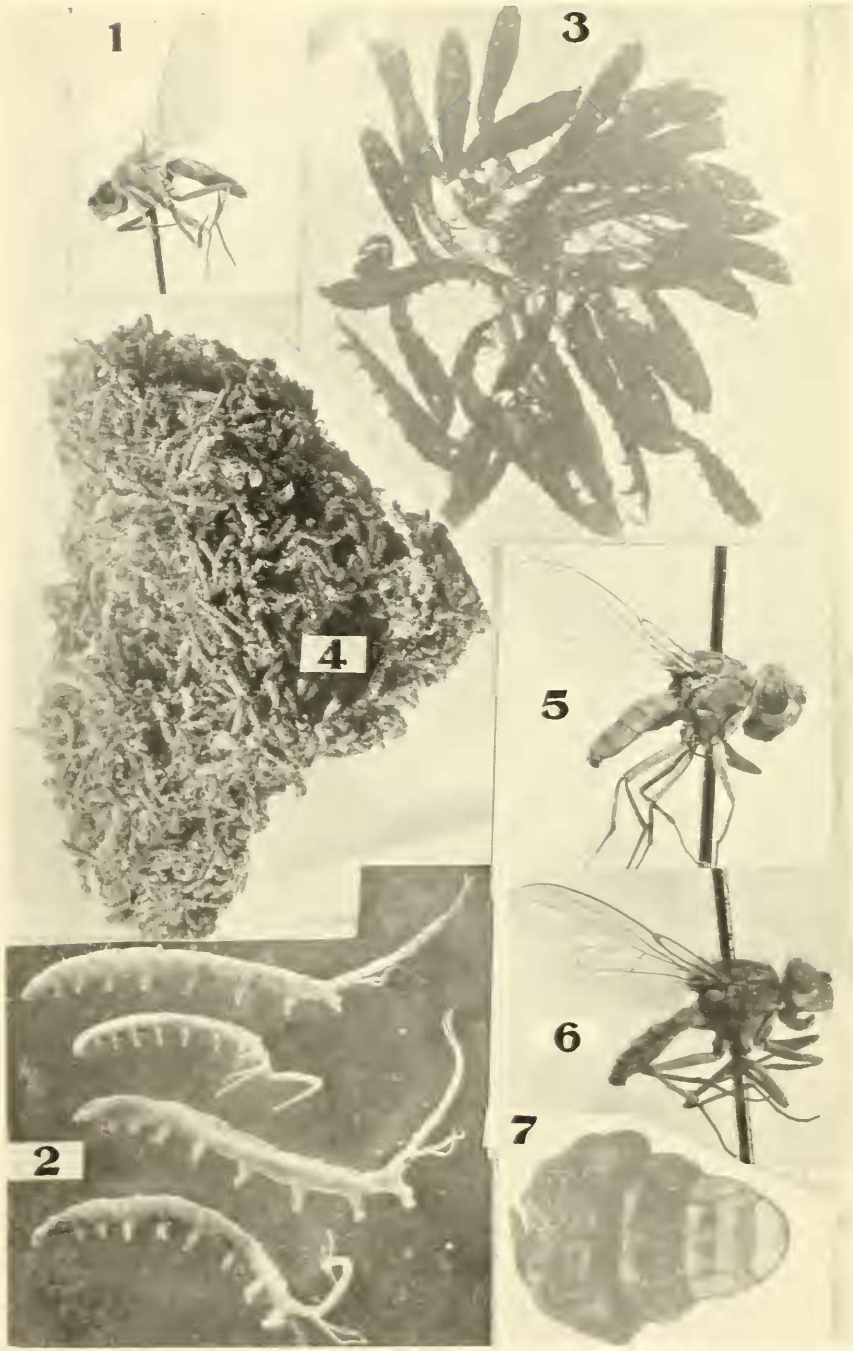
Fig. 9. Looking west on the south side of the railroad near Fig. 8. The puparia of *gracilis* form the dark deposit along the edge of the water.

Fig. 10. *Ephydra gracilis* on railroad rails at Lakeside, Utah; the near rail on the right is focused best.

PLATE III.

Fig. 11. *Ephydra hians* Say, eggs, × 40.

Fig. 12. *Ephydra hians* Say, young larva, × 24.



Western Ephydra.